Reference 7

FINAL REPORT TO U.S. EPA/OUST

CAUSES OF RELEASE FROM UST SYSTEMS

EPA CONTRACT: 68 – 01 – 7053
SUBCONTRACT: 939 – 5
WORK ASSIGNMENT: 24

September 30, 1987

II. TANKAGE

A. BARE STEEL

Estimates provided by very experienced installation contractors (22) were that 50% of tanks in existence could not pass tightness testing five years ago, and their experience suggests that this figure has been reduced by increased awareness, use of new equipment, and contractor education to the point where these contractors presently believe the figure to be less than 20%. About 75% of the existing tank population is of the "bare" steel type, and the majority have been in the ground for at least 10-15 years--the critical time period for their failure by corrosion. The ticking time bomb analogy that has been used in the past concerning these tanks is significantly mollified however, by numerous reported field observations that many existing tanks have at closure been seen to have "plugged" corrosion holes that do not show any evidence of leaking when unearthed. Also, field observations, including several local communities that were visited (for example Austin, Texas) (11), indicate that numerous old tanks of bare steel are being closed which are in excellent shape with no holes. Another example is Suffolk County New York's investigation (16) for EPA which is showing about one third of the older closing tanks have corrosion perforations, and half (or 1/6 of the total) of these show signs of leakage---about half of those studied did not have significant corrosion. Tank testing programs (based on about 10,000 tank system tests) indicate that about 5 to 7% of tanks actually leak when they are tested for the first time. Very few of the tanks less than 12 years old are ever found to have holes.

Generally, most tankage is presently of the "bare" steel vintage; of the total tank population some 70-80% are "bare" steel. This type of tankage is gradually decreasing due to voluntary upgrade programs, local regulation, and the federal interim prohibition. Externally coated and cathodically protected steel tankage, such as STI-P3, account for about 8% of the existing population. Their usage has recently experienced a very sharp increase (since their introduction some twenty years ago). Another 12-15% of the existing tankage is made of fiber-glass reinforced plastic (FRP) construction. Another 8% of the population is a mixture of clad, composite and corrosion resistant metals. The existing UST world is presently estimated to be as follows:

TABLE B

THE EXISTING UST WORLD

Type of Tank	Present Share of Population	Estimated Number in Existence[1]	Future Growth Trend[2]
"Bare" Steel	70-80%	900,000 to 1,000,000	Rapid Decrease
Coated with CP	8%	100,000	Rapid Increase
FRP	12-15%	156,000 to 195,000	Moderate Increase
Composite, Corrosion Resistant	5-8%	65,000 to 100,000	Moderate Increase

[1]Based on EPA's estimate of 1,318,000 UST systems in existence - See Table I of preamble.

[2]Based on PEI meeting, also see Table F.

Numerous tank failure histories indicate that, when failure occurs, 95% of "bare" steel tankage fails from corrosion. There is a wide disparity of opinion about how to assign causes of release due to external, internal, or a combination of both types of corrosion. Accurate data or studies which convincingly differentiate among corrosion causes are very few, and internal tank inspections are not common. Based on opinions of major corporate owners, tank lining companies and independent consultants studies, the estimated spread (Table C) provide a rough approximation of the cause of corrosion holes (about 50% of which are probably rust plugged and don't leak) in "bare" steel tanks:

TABLE C

CAUSE OF CORROSION PERFORATIONS

TYPE OF CORROSION	AVERAGE AGE AT FAILURE	% OF TOTAL CORROSION FAILURE
Internal	10-20 yrs	6-10
External	10-20 yrs	70-80
Combination	10-20 yrs	15-19

Tabulation of testing data from Service Station Testing (64) (Table D) reinforces the data in Table C.

TABLE D

RESULTS OF 980 STEEL TANKS TESTED
(WHERE AGE WAS SPECIFIED)

TANK AGE	NO. OF TANKS	NO. OF TANKS LEAKING	
6 years	190	2	
6-11 years	145	4	
- - - - - -	- - - - - -	- - - - - -	-BREAKTHROUGH OF CORROSION BEGINS
12 years	38	5	
13 years	30	3	
14 years	55	1	
15 years	80	5	
16 to 20 years	252	11	
20 years	190	11	

Data submitted by the Internal Tank Lining Industry (24) supports and substantiates the above results (Table F):

TABLE E

AGE RELATION TO FAILURE

TANK AGE	NUMBER	%
0-5 Years	232	0.9
5-10 Years	1,204	4.9
10-15 Years	7,391	30.2
15-20 Years	10,336	42.3
20-30 Years	4,478	18.3
30+ Years	811	3.4

BASIS: 24,452 Tanks found to be Leaking and subsequently repaired and lined. All tanks are bare steel.

The clarion message from the field on over 90% of tank failures (17, 18, 22, 39) to date is that the primary cause is due to improper backfill: it is not select (clean sand or pea gravel); if select, it is contaminated with rubbish, wood or other soils; or it is improperly placed and compacted. Of all the current failure modes, corrosion of "bare" steel is by far of greatest importance; and the tank manufacturers have responded with exterior coated and protected steel tanks and tanks of corrosion-resistant materials such as FRP.

B. NEW GENERATION TANKS

As early as twenty years ago, manufacturers began to respond with innovations to attack the number one cause of tank failure - exterior corrosion. Tanks began to appear that were all fiberglass reinforced plastic (FRP), steel coated with a non-corrodible resin or plastic and having sacrificial anodes and clad or composite construction. Initial acceptance by owners and operators was slow due to higher initial costs. However, as environmental awareness increased, sales began to rise, slowly at first, but a dramatic acceleration in utilization of new generation tanks occurred with the introduction of the Interim Prohibition. Representatives of the various trade associations for the individual types of new generation tanks have provided sales data for the period from 1980 through 1986 and estimates for 1987 - see Table F.

TABLE F

PRODUCTION OF NEW GENERATION USTs

Year	FRP[1]	Composite[2]	STIP3[3]
1980	9,000	N.A.	N.A.[4]
1981	10,000	N.A.	N.A.
1982	11,000	N.A.	N.A.
1983	12,000	3,000	N.A.
1984	13,000	6,500	7,000
1985	14,000	8,000	14,000
1986	15,000	10,000	28,000
1987(est)	16,000	12,500	45,000

[1]Ed Neshoff, Data from FRPTI.

[2]Bob Holland, Data from Association of Clad Tankers

[3]Wayne Geyer, Data from Steel Tank Institute

[4]N.A. - Not Available

Most existing steel tankage that is coated or FRP-clad on the exterior, or fitted with cathodic protection, is less than five years old. However, some tank systems of this type are at least 15 to 20 years old. So far, reported failures observed in the field due to corrosion (or other reasons) from such tanks are very rare, if any.

Clad tankage is very popular in Sweden and Denmark (70) where officials report their tank problem "has gone away" since such tankage was required in 1972. Clad and composite tankage has been produced in this country for 15 to 20 years in the U.S. There is no known case of a clad tank's failing from corrosion; in fact, manufacturers report today's clad tanks are even better than 10 years ago.

One group of tank manufacturers who have formed the Steel Tank Institute, produce a protected new generation tank, STIP3, of steel coated with a non-corrodible resin or plastic material and have sacrificial anodes for additional corrosion protection should the non-corrodible coating be damaged and the bare steel exposed. Installation contractors (22) in the field report if we used this type years ago, the exterior corrosion problem would not exist today. The STIP3 tank is a favorite of corrosion engineers. Very few failures have been reported and those failures are due to installation damage or improper maintenance, not design (21,22). In the Province of Ontario, Canada, STIP3 tanks have been widely used and the tank releases from corrosion are going away.

FRP tankage appears to rarely fail due to corrosion (e.g., because unanticipated solvents are encountered which are incompatible with the tank resin and dissolve it). Overall, annual failures of all existing FRP tankage appear to have occurred at less than a rate of 0.25% per year of the total of FRP tanks installed nationwide (21) (conservatively computed based on the number of failures in one year--in a total population of 200,000 divided by the number of tanks manufactured in one year). Numerous sources appear to support the field estimates collected by EPA that less than 0.5% of the existing FRP tanks have ever had a problem. Even these small failure rates represent a decline of 50% between 1976 and 1986 as reported by Owens Corning Fiberglass. Failures in FRP tanks have happened very early in the tank's life due to cracking, however most of this type of failure occurred over 10 years ago and appears to be rare today.

The tank manufacturers, several tank owners, as well as installation contractors claim these FRP failures were primarily caused by very poor installation practices or, on very rare occasions, by a defective tank. For example, a group of 8 installers (22) from around the country identified 8 failures in 1500 to 2000 installations, Ashland Oil (48) has recorded only one failure in 107 FRP installations, CAE Fiberglass and the Ontario Government's Fuel Safety Branch (45) reported one failure in 7,000 FRP tanks; Circle K Convenience Stores (39) have recorded one failure in 2000 installations, and The Southland Corporation (12) has recorded 19 failures in 3000 installations. Circle K and Murphy Oil (15) have totally based their new and retrofit programs based on FRP tanks (as have many other major oil companies in the U.S.).

Heightened installer awareness of proper practices and techniques appropriate to FRP technology, manufacturer-sponsored contractor education programs, and production quality assurance appear to be responsible for the present low failure rate of FRP tanks (21). It appears that many of the reported FRP installation failures occurred over 10 years ago (22).

Double wall steel and FRP tankage has been introduced to provide secondary containment for UST releases. Present usage appears to be concentrated in jurisdictions (3,4,5,6,7,8) with sensitive environmental areas. The cost of this type of tankage has decreased since introduction to the market place. One contractor group (22) felt double walled tankage to be one the better potential solutions for tank releases but, they noted lack of operating histories and costs have held voluntary usage at a low level.

C. INTERIOR CORROSION

Interior corrosion of steel tanks appears to be another failure mode with steel tanks (21, 24, 31, 40, 70), but thus far has been largely ignored. New tank designs have addressed and greatly reduced the exterior corrosion failure potential. As exterior corrosion recedes through more preventive measures, it is possible that interior corrosion will eventually become, over the long term, the primary steel tank failure mode. However, the incidence of corrosion induced tank failures is expected to then be significantly less than today and take longer to manifest itself after external corrosion is prevented through new tank designs.

Studies in Sweden and Denmark (58, 70) indicate internal corrosion to be a significant cause of release when storing gasoline and the main cause of release if storing fuel oil. In Switzerland, internal corrosion was found to be the cause of release in 5% of the investigated incidents. In Denmark (18) and Sweden (17) it is considered so severe that internal sacrificial anodes are required and internal inspections are required every 10 years to examine the internal tank structural condition (anode weight is designed to provide protection for a 10 year period).

Numerous contacts in private industry (13, 14, 15, 25, 35, 36, 38, 39, 40) have reported problems with pitting and perforations inside of steel tanks under the drop tube. The tank liners data confirms these reports and the tank industry has voluntarily responded by providing "striker plates" under all openings. (They are required by UL in Canada.) Where internal corrosion is identified generally, the breakdown by location is given in Table G.

TABLE G

LOCATION OF INTERNAL CORROSION

TANK	NO.	%[1]
At the Sludge Line	8,283	58
Upper Tank Pitting	1,228	9
Pitting Under Drop Tube	2,296	16
Pitting in Bottom of Tank	12,291	86
Holes Under Drop Tube	1,652	12
Other	259	2

[1]Percentages add to more than 100% as more than one location was reported for a single tank.

D. INTERIOR LINING

Tank interior lining has been identified as a world-wide technology. In the U.S. it is a widely used technique that has been employed by major corporations (e.g., Amoco (14), Ashland Oil (35), as well as by small owner/operators) as a short term, but effective, solution for both older or perforated and repaired tanks, or as preventive maintenance measure for sound non-leaking tanks. Data received from Ashland Oil (35), Shell Oil of Canada, the Ontario Fuel Safety Branch (10) and numerous data from the tank liners themselves, indicates this to be a successful procedure for extending an existing tank's non-leaking life. Even when employed in the absence of external cathodic protection--failure rates are reported to be very low. This technology is reported to be used widely in Europe (70).

Two tank lining companies (24) have submitted data to EPA that was collected from their installers in the field, this data covers 35,349 motor fuel tanks which have been lined; 26,000 of the tanks were leaking at the time of repair. The tanks were lined with a 120 mils thickness (about 1/8 inch) of coating after the interior tank shells were sandblasted and perforations were repaired. Only 197 tanks have been reported as failed since lining (0.5% of the tanks lined). The tank liner installers also indicated that internal corrosion was a major cause of failure, either alone or in conjunction with external corrosion. Their data further indicates internal corrosion has caused failure in 45% of the repaired USTs. Cathodic protection was not retrofitted on the repaired USTs and, in fact, about 1100 tanks had cathodic protection prior to repair.

E. RECERTIFICATION

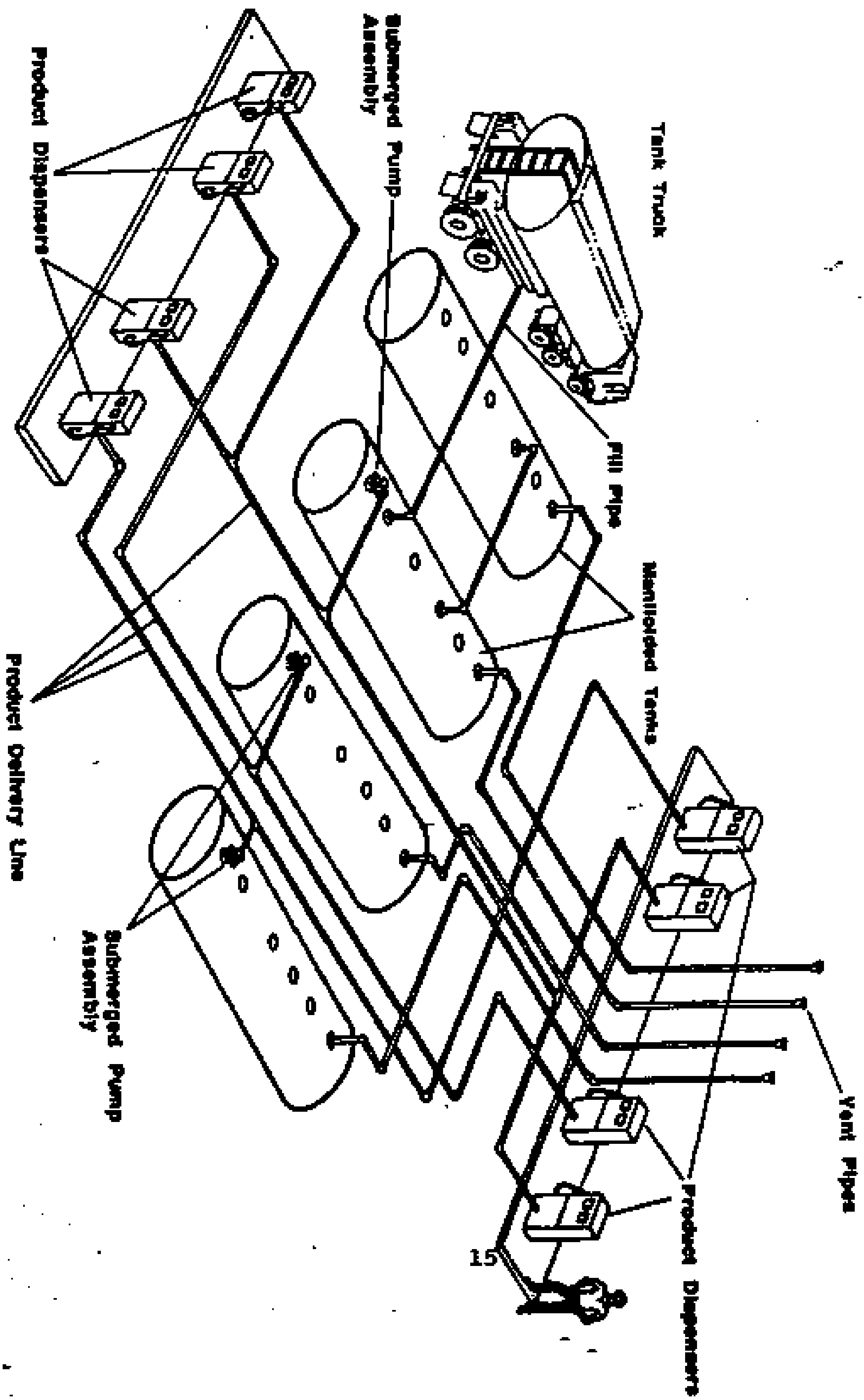
A new area has been identified through the investigation: recertification and reuse of tankage (21). It is apparently not uncommon for some people to dig up and reuse a protected tank elsewhere. Presently this practice has been used with some FRP tankage and FRP tank manufacturers offer recertification, warranty continuance and even warranty transfer to third parties. Additional information on procedures, criteria for acceptance and the possible extension to steel tankage maybe necessary in the future as more of the long-lasting new tank varieties are placed into service in one location and then later moved. The Steel Tank Institute and API have reported to EPA that they do not foresee this as an area of immediate concern.

III. PIPING

The preamble to the proposed EPA regulation cited reports that indicate the contribution of product delivery piping as a cause of release to be less than that of tanks. However, virtually all field contacts made over the last several months rate delivery piping or fittings on top of the tank as the primary cause of release and estimate that it was responsible for 80 to 85% of all releases. Actual files and written databases on this subject appear to be few and imprecise. Most local regulatory release incidents reports did not distinguish between piping or tank releases. Where they do exist they are usually the assumptions of inspectors in the field who see only the disinterred tanks, because the piping is often left in the ground. The primary cause of piping failure is cited to be installation practices and techniques. The complexity of a typical piping system may be appreciated by examining Figure 1 which schematically shows the amount of pipe, numbers of fittings and changes of direction in a typical retail motor fuel outlet. Each joint is a potential leak source.

Two types of piping (delivery) systems are now employed in dispensing product from USTs: suction and pressure. Presently several experienced contractors estimate a roughly equivalent use of both systems in the retail motor fuel sector; however, 95% of the new UST systems in high volume retail applications are reported as installing the pressurized type while 90% of the new and existing non-retail motor fuel installations are still of the suction type system.

FIGURE 1



Typical Four-Tank Station

TABLE H

ESTIMATED USAGE OF PRESSURE AND SUCTION DELIVERY SYSTEMS

	% SUCTION	% PRESSURE
Existing non-retail motor fuel sector: (Approximately 705,000 tanks)	90%	10%
(New tanks)	(90%)	(10%)
Existing retail motor fuel sector: (Approximately 676,000 tanks)	40%	60%
(New tanks)	(10%)	(90%)

There also is reported to be a wide variation in the potential size of releases from the two types of piping systems. Service Station Testing (64) found 9.2% of pressurized piping systems (of 1351 total tests) and 6.8% of suction piping systems (of 474 total tests) non-tight.

In the absence of large databases, several experienced contractors (22, 24, 47, 64, 69) have been consulted. Contractors repair and remove systems as well as install them and have continuing exposure to the primary causes of line failures. Their consensus was that piping systems do not enjoy the same longevity as tanks. Frequent modifications and routine alterations at the tank site tend to reduce the undisturbed life span of piping. Their field experience indicates failures can be attributable to two factors: corrosion and leaking joints - which are commonly induced by poor installation practices. If line systems were left in place for 30 years, contractors believe failure from corrosion would account for a 20% failure rate and damaged or loose fittings for another 40%. Corrosion is precipitated by non-select backfill and contaminated backfill; therefore clean (select and uncontaminated) backfill should greatly reduce the corrosion problem, but some type of cathodic protection is still required.

Presently no pre-engineered cathodic protection is available for piping, most steel piping is currently protected by galvanizing, coating and wrapping, or coating alone, and the threaded portions at joints is the most common failure point because the protection is removed while threading and never replaced. If threaded steel pipe is used, some type of sacrificial anode system for cathodic protection would eliminate some fitting failures due to installation errors. Fitting failure is from either corrosion, untightened joints, cross-threaded joints or improperly made joints. Contractor education and skills in the complex pipe installation task need to be improved.

Piping systems are of two materials of construction: metal or FRP. The contractors (22) suggest that they both have unique advantages and disadvantages.

Both installer/contractors (22) and owners (12, 39) have estimated that piping is damaged 10% of the time at new installations sometime between the completion of installation of equipment and completion of paving. Therefore, they clearly recommend that some type of pre-start-up function test is essential as a sound practice, particularly with pressurized piping.

TABLE I

COMPARISON OF THE COMMON MATERIALS USED IN UST PIPING SYSTEMS

	METAL PIPING SYSTEM	FRP PIPING SYSTEMS
1.	SUBJECT TO CORROSION	NON CORROSIVE
2.	HEAVY	LIGHTWEIGHT
3.	HIGH RESISTANCE TO CRUSHING/FRACTURE	LOWER RESISTANCE TO CRUSHING FAILURE
4.	JOINTS FAILURE BY TENSION-LOWEST POTENTIAL	JOINT FAILURE BY TENSION-HIGHEST POTENTIAL
5.	LITTLE FROST HEAVE FAILURE	HIGH FROST HEAVE FAILURE
6.	HIGH PUNCTURE RESISTANCE	LOW PUNCTURE RESISTANCE
7.	SPECIAL SKILLS REQUIRED FOR ASSEMBLY	SPECIAL SKILLS REQUIRED FOR ASSEMBLY
8.	FABRICATION TOOLS REQUIRE CONSTANT CARE AND ATTENTION	FABRICATION TOOLS INEXPENSIVE THROW AWAY TYPE
9.	COLD DOES NOT AFFECT FABRICATION	CATALYZED JOINT CEMENTS REQUIRE 60°F FOR PROPER CURE

A. SUCTION DELIVERY SYSTEMS

Suction dispensing lines are considered much more intrinsically safe than pressurized lines because they operate at less than atmospheric pressure between the tank and the dispenser; thus, during operation fluids outside the pipe will leak in while the conveyed fluid will not leak out. This simplistic approach generally leads some to a conviction that a suction system should be used in all cases and pressure systems not employed. However, a closer comparison of the two systems indicates that the suction type is not always the most ideal operating type of system (See Table J).

While suction systems offer the least expensive approach to reduce the threat of piping-related releases, they do not work well at high altitudes, in hot climates or in high-volume delivery situations.

TABLE J

COMPARISON OF PIPING SYSTEMS

	SUCTION TYPE	PRESSURE TYPE
1.	NEGATIVE DELIVERY TO DISPENSER	POSITIVE DELIVERY TO DISPENSER
2.	LIFT INCREASES PUMP WEAR	FLOODED SUCTION-NO CONTRIBUTION TO PUMP WEAR
3.	VAPOR LOCK FROM ALTITUDE OR HEAT	NO VAPOR LOCK
4.	MAXIMUM LIFT IS 15 FEET (LIMITS BURIAL DEPTH OF TANK)	NO LIFT PROBLEM-(UNLIMITED BURIAL DEPTH)
5.	LITTLE OR NO RELEASE TO ENVIRONMENT	POTENTIAL FOR LARGE RELEASES TO ENVIRONMENT
6.	PIPING DESIGN, LAYOUT VERY CRITICAL	PIPING DESIGN, LAYOUT LESS CRITICAL
7.	INHERENT RELEASE PREVENTION	ADD-ON RELEASE PREVENTION

Review of suction systems with contractors (22), owners and equipment manufacturers indicate that suction systems cannot be utilized in all situations. The maximum lift capability of a suction pump is reported as fifteen (15) feet. Due to the lift restrictions of the pump, a nominal tank of 10 foot diameter with 2 feet of cover, the tank would have to be located within 50 feet of the dispenser as the lift is consumed by line friction losses. Additionally, manifolding of suction delivery lines cannot be practiced which requires additional lines per site, increasing installation costs and increasing the potential release sites. Ideally, the tank also should be located directly below the suction pump and the lift requirement held to a minimum to reduce wear on the pump.

The location of the check valve in a suction piping system has been of concern. In Europe (70), the check valves are located just below the pump; in the United States, most check valves are located at the beginning of the suction line near the bottom of the UST, which maintains the product delivery line full of free product at all times. Placement of the check valve at the top of the tank is also practiced. Utilization of a foot valve is beneficial in reducing a pump's power consumption and the wear and strain on the pump. However, placement of the valve near the dispenser is beneficial in reducing the volume of a potential release, as the product will drain back into the tank in preference to through a hole in the pipe and into the environment.

B. PRESSURIZED DELIVERY SYSTEMS

Pressurized piping systems are reportedly on the increase in the retail motor fuel sector, representing about 95% of new retail motor fuel systems installations (22). The turbine pump is submerged in the product in the tank; the piping from the pump discharging to the dispenser is normally at operating pressures of 30 pounds per square inch. A check valve next to the submerged pumps discharge point is used to maintain the fluid in the line at operating pressure during product delivery, the pressure is reduced to 8 - 12 PSI and held even while the pump is not operating. Should the delivery line be breached, free product will be released until the pressure in the pipe is reduced to the pressure outside the pipe and equilibrium is established. Without add-on instrumentation or devices, this pump can rapidly push large volumes of product out of breaches in the line during operation when product is called for (at the dispenser). However, in a leaking line product will generally not only be forwarded through the dispenser to a customer, but also through the hole into the environment at the same time. The pump simply pushes more volume to meet this dual increase in demand.

The consensus from the field was that releases from pressurized piping systems clearly can be catastrophic in the absence of monitoring and automated pump flow restriction devices - one incident of a release of 20,000 gallons in one day was reported (22). While such catastrophic high volume releases are the exception, the field experiences of nine contractors cited their ability to recall easily over one hundred and fifty large volume pressurized releases. One contractor's field observations included estimates of a typical size range of between 600 to 6,000 gallons without the use of automatic detector/flow restriction devices. However, even with the use of these commonly available devices, the expected high number of release incidents from piping at rates of 3 gallons per hour or less would still indicate a substantially larger volume of product being released from pressurized piping than from tanks. For example, in Dade County, Florida (9), piping releases account for 21% of all written data on releases (215 incidents from 1984 to April 1987). Line losses by volume are tabulated from Dade County files as:

TABLE K

DELIVERY LINE PRODUCT LOSSES

DADE COUNTY, FLORIDA
1984-1987

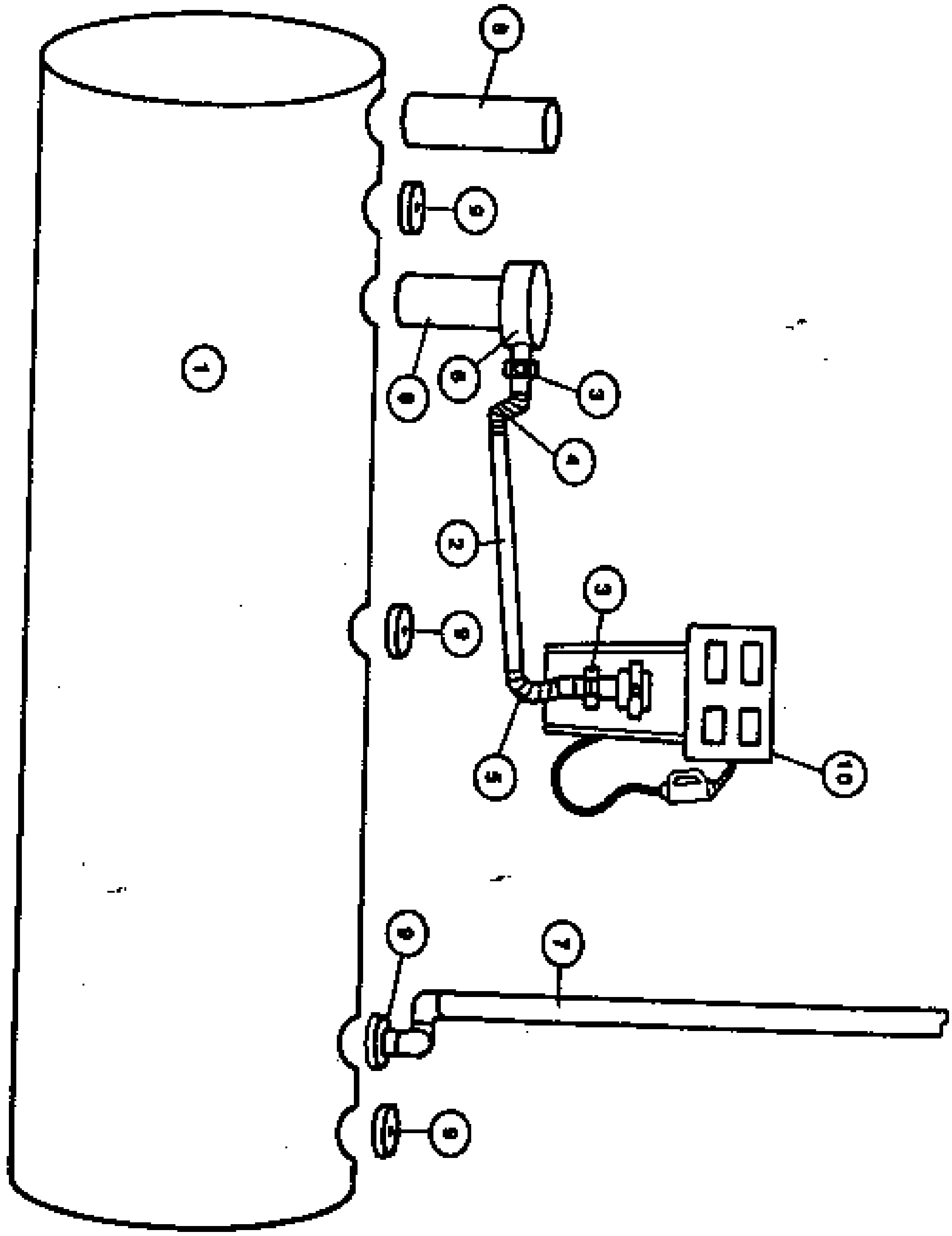
No of Incidents	Volume of Release
2	10-99 Gallons
3	100-499 Gallons
3	500-999 Gallons
7	1000-9999 Gallons
2	10,000+ Gallons

As previously mentioned, one very experienced contractor/line tester reported pressurized line leaks as commonly falling into the 600 gallon to 6,000 gallon range. The most common and readily available automated, in-line pressure device reduces the release rate, but does not stop the release; however, if it is carefully monitored or maintained, it is reported by several experienced contractors/installers to have significant mitigating value. Unfortunately, about half of all owner/operators with pressurized lines were reported to have not installed these devices in an effort to reduce their initial investment capital outlays. If installed and properly monitored and maintained, one experienced ad hoc workgroup (22) of installation contractors estimates that 70% of the volume of product lost through pressure pipe releases from existing UST systems could be avoided (within two to three years) by retrofitting each line with a simple, inexpensive continuous in-line pressure monitor that automatically restricts product flow in the presence of a significant line leak. Present models of these devices are commonly reported by installers to be more dependable and fail safe. (A maximum retrofit cost of $1,000 has been indicated, but with a typical total cost of $500 per pump in 80% of the cases.)

Several companies are now performing simple pressure tests on piping on an annual basis. Pressure is applied from the impact valve back to the pump's check valve, the pressure is observed over a 30 minute to 1 hour period for decay. Loss of pressure instigates more detailed investigation which has located faulty line leak detectors, loose fittings, faulty check valves and line corrosion failures. The cost of an annual test of this nature is from $300-$500 per site. (This type of test could be utilized to test suction systems also.)

A potential method of continuous monitoring of pressurized lines has been identified. A pressure gauge could be installed at or near the dispenser and the gauge observed during periods of dispenser inactivity. A loss of pressure to less than 5 psi in thirty minutes would indicate potential loss of system integrity. The additional cost for this check at new installations would be in the $25 to $35 range; however, care to bleed all air from the line prior to gauge installation is necessary. Sophisticated remote monitoring using pressure transducers would raise the cost into the range of $500 to $600 per dispenser.

FIGURE 2



Typical Tank System Assembly

1. Tank
2. Product Line Piping
3. Unions
4. Swing Joint
5. Flex Hose
6. Submerged Pump
7. Vent Line
8. Fill Pipe Riser
9. 4" Plug Into Tank Bung
10. Dispensing Unit

IV. NON OPERATIONAL COMPONENTS

Numerous data has been obtained primarily from several commercial tank testing surveys (64) concerning the field performance of non-operational components of tank systems. The testing was most often due to local government testing programs, and the data available to EPA corroborates a widespread failure of non-operational components of the tank system. These components provide the most common source of system non-tightness under conditions of a standpipe tightness test. These non-operational components consist of: (See Figure 2)

A. Tank bung holes
B. Tank manholes
C. Vent and fill lines
D. Vapor recovery lines
E. Manifold piping (connects tanks together)

These components are called non-operational because releases from these sources are episodic and of small volume when they occur because they only occur when an UST is overfilled or manifoleded tanks are filled through one of the connected tanks' drop tube. In other words, they do not leak under normal operating conditions because they are located above the top of the tank.

Releases from the following common sources are reported (22) as the result of improper installation practices:

1. Tank bung hole protectors are not replaced with screw-in plugs at installation.

2. These bung plugs are not tightened at installation.

3. Vent lines are fabricated of the wrong material, e.g. PVC.

4. Vent line and vapor line joints are not tightened or cemented because they only contain "air".

5. Poor backfill or site selection give rise to tank settling.

6. Vehicular traffic can damage vent line and fill pipe connections to the tank.

7. Improper cover or pavement thickness can lead to damage from normal traffic.

Service Station Testing Company (64) in San Antonio, Texas, has performed in excess of 3700 tank and system tightness tests. Of the systems tested, 364 were found to be non-tight and 272 (74.7%) of the test failures were the result of non-tight tank fittings or vent lines.

In the "Summary of City/County Reports" (67) it is noted that 13% of the identifiable causes of release are directly attributable to loose tank fittings. A 1986 draft EPA report (68), in 1986, which investigated 158 release incidents found that 15.5% of the releases are attributable to fill pipes and vent pipes.

Numerous unreported incidents are believed to have also occurred to date. Preliminary results from an on going EPA sponsored investigation in Suffolk County (63), N.Y., that has been corroborated by numerous installation contractors nationwide, report that exhumed bare steel tanks show evidence of non-operational sources of leakage which has been seen to deteriorate the exterior bitumen or asphaltic coating on the tank shell. The deterioration is traceable to leaks at fill pipes, vent lines and bungs from the pattern of deterioration and the discoloration of surrounding soils. Additionally, recently released free product was sometimes in evidence in the soil surrounding the UST.

Releases from these non-operational components are difficult to detect without the use of precision tightness tests or exhumation of the top of the tank system, because the release occurs only when filling a tank or overfilling occurs, these releases are too small to be detected by any inventory monitoring system.

Two avenues are obviously available to stop this type of release: ensure proper installation or eliminate overfills. Elimination of overfills is believed to be the most fail-safe remedy and probably the easiest to implement. For example, a recent EPA visit to a prominent tank manufacturer revealed they are still having significant problems in getting tight bong hole covers applied at the factory. If the stored product is never allowed to reach these system weak points, above or on top of the tank then it can never be released. This appears to be the widespread approach to addressing the problem in several European countries.

V. SURFACE RELEASES - SPILLS AND OVERFILLS

Spills and overfills (along with the ensuing releases from non-operational components) are probably the most common type of UST related release to the environment. It is believed that most incidents go unreported due to the typically small volume of product lost (less than 20 gallons). Most excavated "bare" steel tanks show evidence of spilled material, e.g., asphaltic coating near the drop tube bung has been dissolved, discolored soil is present, etc. Regulatory officials in Dade County, Florida (7), cite spills/overfills as the primary cause of release-- 45% of incidents reported--and twice the tank or piping problem.

TABLE I

SPILLS AND OVERFILL LOSES

DADE COUNTY, FLORIDA (9)
1984-1987

NO. OF SPILLS	VOLUME OF SPILLS
9	10-99 Gallons
5	100-499 Gallons
3	500-999 Gallons
3	1000-9999 Gallons
0	10,000 + Gallons

Data from Virginia's State Water Control Board (23) documents spills and overfills being responsible for 12% of all UST related releases. Documentation of European (70) experience cites 63% of releases due to overfilling and 65% of these overfill releases were less than 265 gallons.

Experienced installation contractors (22) carefully and repeatedly suggest that spills and overfills should not be lumped together, they point out that attempts to control one may not control the other. Spills are reported to usually occur at the time delivery hoses are disconnected from the tank fill tubes, because the delivery hose either was not drained or the disconnect stop valve (on the truck's fill tube) was not completely closed. Overfills are primarily a result of the failure to gauge a tank's available capacity against the quantity being delivered.

Informal discussions conducted by EPA with an ad hoc installation contractor group (22) pointed out that deliveries were often made at night, and drivers are in a hurry because they are paid by the loads delivered, not by the hour. Two former delivery truck drivers in the group estimated the following frequency and size based on their own experiences with the industry.

The spilling or dumping of small amounts of product, as cited by these former transporters, hasn't been previously seen as an environmental problem in the industry. Its curtailment was only governed by the ethic of not wanting to throw away valuable product. However, in the middle of the night with no one else around, a delivery route only partially completed, and nowhere else to put excess product, circumstances dictated throwing it away "down the hole". Several corrective steps have been suggested to stop this bad practice. (Table N)

Numerous European countries appear to have been requiring the use of overfill protection devices. Switzerland, West Germany, France and Sweden (70) require automatic shut-off overfill devices. Automatic sensor shut-offs in addition to other automatic shut off devices are utilized in Europe. Ball float valves have been employed in the United States but operating difficulties have arisen in conjunction with coaxial vent and vapor recovery systems (ball float rises and stops delivery flow due to the reduced relief capacity of the vent line).

Catchment Basins are also available and sometimes used, in the U.S. to contain small spills from hoses during the delivery process. They are positioned to surround the top of the fill tube and (depending on design) hold from 5 to 45 gallons of product. Generally, they must be manually drained into the tank after the product level in the tank drops, through dispensing of product. Numerous contacts cited reservations/operational problems concerning the use of catchment basins.

1. Water accumulation (due to rainfall) which is erroneously dropped into the tank and can facilitate internal corrosion especially if salt (in the air) is present (as in Northern and Coastal Regions).

2. Failure to drop the contained fuel into the tank can allow a safety hazard to develop because fuel in the basin will foster vaporized gasoline and air to combine and make a potentially explosive mixture.

3. Crossing vehicular traffic can cause friction between the metal cover and lid over the basin cover creating sparks that fall into the reservoir.

4. Transporter failure to inform the owner/operator that material has been spilled into the basin which exacerbates the above cited problems.

Elimination and containment of spills and overfills is an area where new and improved equipment are fast becoming available. Numerous contacts with the field suggested they should be encouraged.

TABLE M

TRANSPORTER ESTIMATES OF SPILLS AND OVERFILLS (22)

Frequency	Size of Spill/Overfill
1 of every 25 deliveries	spill 3-5 gallons
1 of every 100 deliveries	overfill and release 20-30 gallons

TABLE N

POTENTIAL CORRECTIVE ACTION FOR SPILLS AND OVERFILLS

CORRECTIVE ACTION	ADDRESSES	ADVANTAGES	DISADVANTAGES
Tank manual dipping at delivery	Overfill	Fast, inexpensive	Degree of accuracy, human error
Automatic level indication	Overfill	Degree of accuracy	Expensive to install
Ball float check Valve	Overfill	Simple, automatic	Problems with coax vapor recover & vent systems positioning at installation (22)
Leak Tight Disconnect on Hoses	Spills	Fast, Inexpensive	Maintenance
Catchment basins (14, 15, 22, 24)	Spills/ Overfills	Contains small quantities (up to 40 gallons)	Manual draining, explosion hazard, water contamination of product
Driver (20) Education & Certification (Maryland)	Spills/ Overfills	Inexpensive (To Owner)	Human error
Civil Fines (2, 3) (San Diego)	Spills/ Overfills		Failure to Report